Department of Electronic & Telecommunication Engineering
University of Moratuwa

B.Sc. Eng. Semester 8

EN 4353 – Radar and Navigation

Assignment 1

Objectives:

- Cloud detection and target extraction from a raw video signal

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Description

Cloud detection is a vital component in civilian radars. Rain clouds can have random downdrafts and updrafts which can cause unpredictable changes to the lift force on the wings of an aircraft. Therefore, they must be avoided by pilots. As an EN4353 student, your task is to help develop an algorithm to differentiate and visualize clouds from a raw video signal.

You are given three files (*Test_case1.csv*, *Test_case2.csv*, and *Test_case3.csv*), which contain the input for first three test cases. Each test case contains **18000** samples of the output present after demodulation. These samples are taken at a very high sampling rate (**1080 kHz**) to give you the essence of a continuous signal, so you are expected to down-sample the signal to fit into **30 range slots**. Your task is to use this demodulated signal to identify clouds and targets present using threshold detection and post detection integration. For threshold detection use a **window size of 21** on the original samples (samples taken @ 1080kHz) to determine the average noise voltage for a particular range slot. A **guard band of 4** would be appropriate in this case.

(**Hint:** Use $V_{TH} = (V_n)_{avg} + k \times \sigma_n$; with an appropriate value for *k*)

Output of a few example cases are given in the proceeding sections to illustrate the procedure. In the presence of clouds identify the rough contour depicting the cloud.

In the presence of a target, indicate the range and the azimuth angle assuming the initial azimuth angle is zero. If a target is detected between pulses *n* through *m (m>n)*, calculate the azimuth angle as follows:

$$Azimuth\ angle = \left\lceil n + \frac{m-n}{2} \right\rceil \times \frac{Radar\ Rotation\ Speed\ (deg/sec)}{Pulse\ Repition\ Frequency}$$

Radar Description:

- Raw Video Sampling Rate = 1080 kHz
- Pulse Repetition Frequency = 1800Hz
- Horizontal Beam Width = 2°
- Radar Rotation Speed = 12 RPM
- $\sigma_n = 1$

Submission Details:

You are expected to use **Python** language to implement your algorithm. The details of the algorithm must be properly explained in your report along with the necessary calculations and visualization. Additionally, you are expected to submit all your codes preferably as a python notebook (***.ipynb)*** with comments and figures (Use rich text fields for explanations and to show calculations). Include simple instructions to run your code as we may use an undisclosed set of test cases to evaluate your algorithm. A clean and a tidy code is appreciated.

Nomenclature:

We use the following encoding to classify objects,

- 1 – Cloud
- 0.5 – Other objects
- 0 – No object

Example output (**Note:** the number of pulses and ranges slots are different):

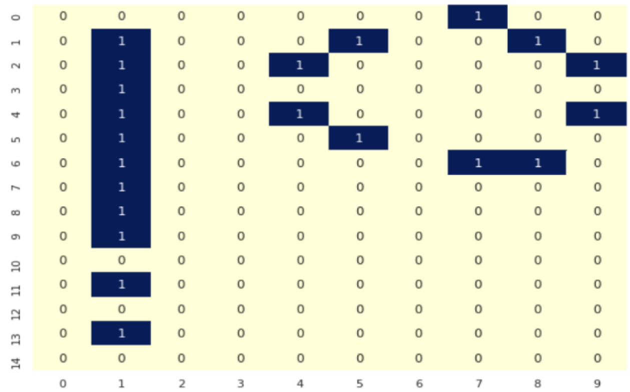

Figure 1: After processing raw video

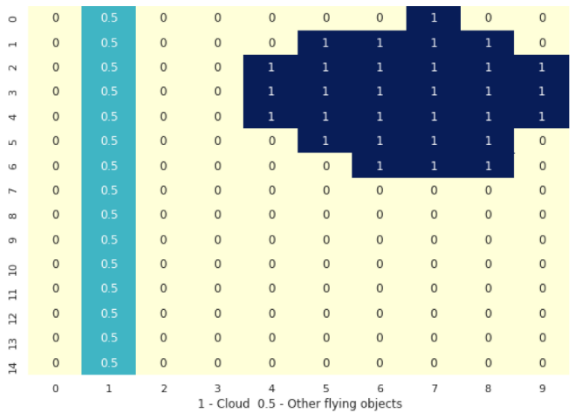

Figure 2: After noise filtering, contour completion and encoding

Tips:

- You might have to implement addition filters to get rid of noise and outliers
- You can use Google Colaboratory to develop your jupyter notebook
- To visualize the output, you can use the following libraries:
  - Seaborn
  - Matplotlib